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BEHAVIOR ANALYSIS OF MOTION CONTROL FOR PEDIATRIC NEUROIMAGING

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Magnetic resonance imaging is a promising technological advance used for research and diagnosis of disease. The procedure has no risks, except when uncooperative patients require sedation. Four normal children participated in simulated scans to study the effects of (a) antecedent changes in the imaging environment and (b) operant conditioning of movement inhibition. Changing the environment can decrease movement, but operant contingencies were necessary to decrease movement to a level that, in most cases, would allow the procedure to occur without sedation.

DESCRIPTORS: behavioral pediatrics, feedback, magnetic resonance imaging, movement control, patient compliance

Magnetic resonance imaging (MRI) is a noninvasive tool for viewing internal anatomy. Patients lie in an enclosed, noisy machine for 20 min or more. Movement decreases image resolution, but the exact movement threshold for a failed scan is unknown. The usability of the images can be evaluated only by viewing them after staff and scanner time has been invested. Sedation is ordered in half of all pediatric cases and, in most children under 7 years old, to prevent movement. Sedation adds risk of transient hypoxia, prolonged profound sedation, and respiratory depression (Hubbard, Markowitz, Kimmel, Kroger, & Bartko, 1992).

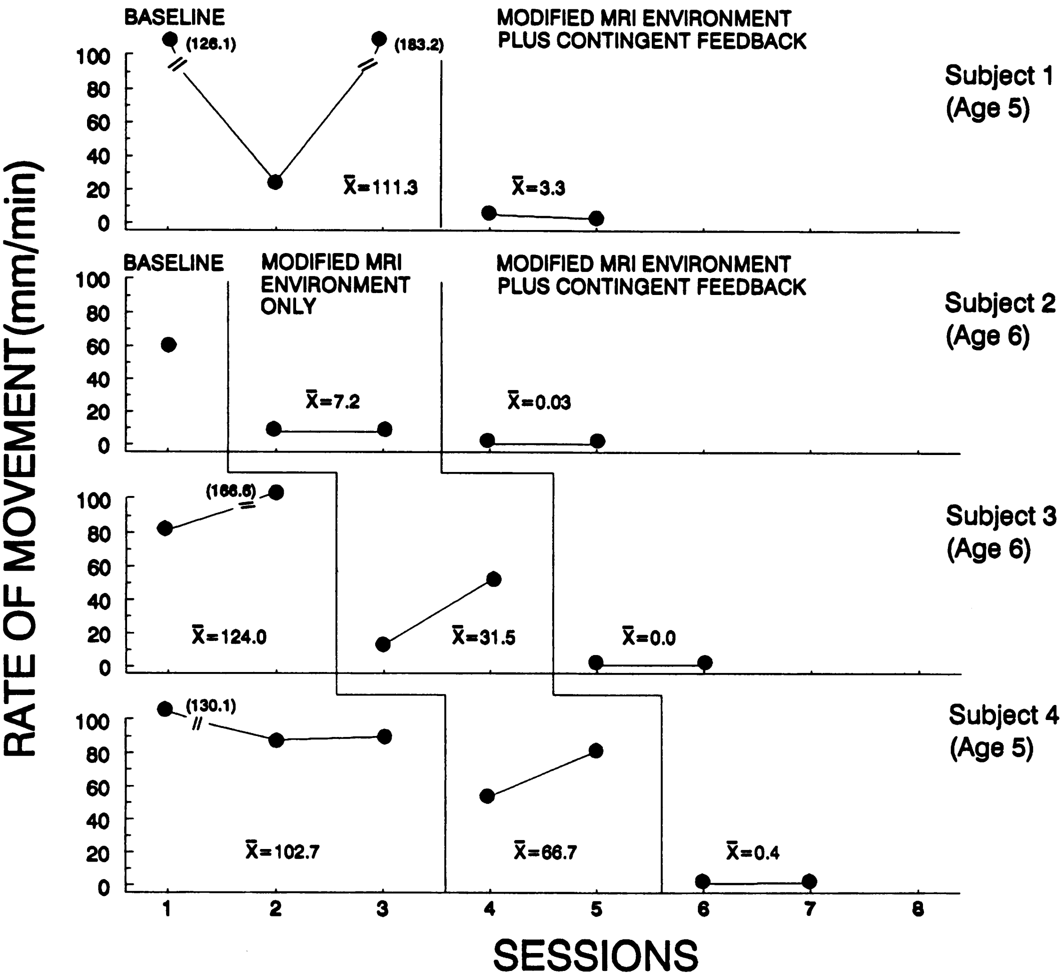
Slifer, Cataldo, Cataldo, and Burke (1989) reported using contingent videotape viewing plus token reinforcement with a 94% success rate for patients meeting a movement criterion of 2 mm per second or less during a 20-min simulated scan. These individuals subsequently cooperated with actual MRI scans without sedation, and the resulting images were judged by medical staff to be of good quality. These subjects were not acutely ill, in pain, or in urgent need of MRI, but included a range of ages (5 to 46 years), developmental disabilities, and psychiatric diagnoses. However, functional control was not demonstrated. The present study demonstrates functional control over normal children's movement during simulated MRI scans and conducts a partial component analysis of the Slifer et al. (1989) procedure.

METHOD: Subjects were normal children who, with parental consent, volunteered for simulated scans. There were 2 boys and 2 girls (5 and 6 years old) from middle-income families with no developmental or medical disorders. The simulated MRI (using an inactive scanner) lasted 20 min (the length of a brain scan). A helmet-like "head coil" covered the child's face, with vision possible through a mirror (standard on MRI scanners). Head supports and safety straps used during MRI were used during simulation. The examination table moved mechanically, and taped scanner noises were played at high volume.

Movement was measured with precision potentiometers (Technology Instruments Corp.). Potentiometers have often been used to measure movement in biomedical research (e.g., Melvill-Jones, Guitton, & Berthoz, 1988). The apparatus was connected to the child's forehead by nylon string and an adhesive patch. Head movement activated the potentiometers, which translated movement into analogue electrical signals. A microcomputer converted analogue to digital data, with head movement measured in millimeters. The average rate (per minute) of head movement during each scan was calculated by dividing cumulated millimeters of head movement by the scan duration. The reliability of the apparatus was tested using an X-Y measurement device (Vertical Horizontal Turret Milling Machine, Enco Manufacturing Co.) to produce premeasured mechanical movements that were measured by the apparatus with a mean error of 0.38 mm (range, 0 to 1.3 mm).

The child was positioned in the scanner and told to hold still. The apparatus was attached. Three conditions were presented in a multiple baseline design. In the baseline condition, the environment was arranged according to usual clinical practice. There was no entertainment or feedback during the scan, and a toy was given at the end of the scan. During the modified MRI environment (noncontingent cartoon) condition, the scanner was covered with a cartoon facade, and the child could watch a preferred cartoon videotape reflected on the head-coil mirror. The soundtrack was played through earphones, which are usable during an actual scan, to be heard over the scanner noises. A toy was given noncontingently at the end of the scan. For the modified MRI environment plus contingent feedback condition, operant conditioning was added to the preceding condition. Viewing the cartoon videotape was contingent on movement of 2 mm per second or less; any head movement exceeding this criterion (Slifer et al., 1989) automatically discontinued the videotape for 3 s. Compliance with this criterion was reinforced with praise and edible items. Reinforcement was communicated verbally (via the scanner's intercom) and by placing the edible item in a cup within view through the head-coil mirror. Edible items served as tokens for a preselected toy and were eaten after the scan.

RESULTS AND DISCUSSION: Data for all 4 subjects are presented in the figure. Introducing environmental modifications alone for Subjects 2, 3, and 4 resulted in movement reductions that did not reliably meet the criterion thought necessary for successful imaging, and movement increased during the second session of this condition for Subjects 3 and 4. The combined intervention immediately reduced head movement to very low rates for all subjects. These data, along with previous clinical outcome data (Slifer et al., 1989), support the use of operant conditioning to teach children to cooperate with MRI and thus avoid sedation. This study and our clinical experience suggest that this procedure would be most useful



for elective diagnostic procedures and MRI used for research. That is, we do not expect our approach to generalize to children who are acutely ill, in pain, have diminished consciousness, or require emergency diagnostic procedures.

The following questions might be considered in future research: Which of the operant contingencies included were necessary? Would more exposure to the patient-friendly environment eventually produce an acceptable level of motion control? What operant techniques could be used for emergency procedures and when children are ill or injured? Would similar operant techniques be successful for imaging parts of the body other than the head? A pivotal study might compare the effectiveness of behavioral training to sedation in terms of safety, cost effectiveness, and image quality.

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